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VOICE DISCRIMINATION AND RECOGNITION ARE SEPARATE ABILITIES

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Abstract—Studies of brain-damaged subjects indicate that recognizing a familiar voice and discriminating among unfamiliar voices may be selectively impaired, and thus that the two are separate functions. Familiar voice recognition was impaired in cases of damage to the right (but not the left) hemisphere, while impaired unfamiliar voice discrimination was observed in cases with damage to either hemisphere.

INTRODUCTION

THE MAJORITY of papers on "speaker recognition" describe the discrimination of unfamiliar voices, as if *discrimination* and *recognition* were variants of a single cognitive process [3, 5, 9]. For example, only 8 of 57 studies cited in a review by BRICKER and PRUZANSKY [3] used familiar voices; the others used unfamiliar voices in tasks including ratings and discrimination, or recognition after training. Investigations of the acoustic "features" or characteristics that underlie this process is obviously a challenging prospect; however, intuitively it seems that the inner process surrounding recognizing the voice of one's friend is very different from that of discriminating among unfamiliar voices.

The research presented here indicates that discrimination of unfamiliar voices and recognition of familiar voices are indeed independent and unordered cognitive abilities. Our previous studies on normal subjects [9, 10] led us to hypothesize that these two tasks engage different cerebral mechanisms. The performance on recognition of backwards voices (in which different voice parameters were observed to influence the identification of different voices) led us to conclude that recognizing a familiar voice is essentially a pattern-recognition process, whereby a holistic Gestalt (the unique voice pattern) is matched to a name/person. On the other hand, unfamiliar voice discrimination may involve featural analysis to a greater extent in the process of matching of basic auditory parameters to judge whether two voices are similar or different—as well as overall pattern recognition. One current model of cerebral hemispheric specialization associates pattern-recognizing abilities with right hemisphere function [1, 8], while analytic processing is specialized in the left hemisphere [2, 4]. Thus one would expect voice recognition and discrimination to differently engage the two hemispheres.

Studies were designed to test the hypothesis that discrimination and recognition are separate abilities with different neuroanatomical substrates. Two listening tasks were developed, one consisting of *unfamiliar voices* for a discrimination task, and the second of *familiar voices* (those of famous men) for a recognition response. If discrimination and recognition were ordered stages of a single perceptual process, then experimental variables should affect them more or less uniformly and, further, one would not expect to find listeners who, given similar tasks, could recognize familiar voices but not discriminate unfamiliar voices.

METHOD

Subjects

Forty-five consecutively available brain-damaged (BD) patients were tested. Thirty-two subjects (11 with right (R)BD, 15 with left (L)BD, and 6 with bilateral BD) received both the recognition and discrimination protocols, while 13 (10 RBD and 3 LBD) were tested on the recognition protocol only. Brain-damaged subjects ranged in age from 34 to 82, with an overall mean age of 61.8 yr (LBD: 61.1 yr; RBD: 59.3 yr; Bilateral: 69.0 yr); all groups ranged from 10–19 yr in formal education. All were right-handed; all had normal vision with correction; most had normal hearing. A few subjects had mild to moderate high frequency hearing losses. Subjects' audiograms were examined, and no relation between performance on either task and patterns of hearing loss was observed. The tendency of some RBD patients to neglect the left-half visual field was compensated for by vertical display on the response sheets. Site and etiology of brain lesion were determined from CAT-scans, EEG testing and neurological evaluation. Clinical assessments were carried out by a neuropsychologist and a speech/language pathologist. Forty of the 45 patients had lesions resulting from a stroke. Two had undergone craniotomies and three had lesions from hemorrhage, meningioma and tumor, respectively. Time post-onset ranged from 2 months to 2 yr for the LBD group, from 2 months to 1 yr for the RBD group, and from 1 month to 2 yr for the Bilateral group. All of the LBD patients were aphasic.

Forty-eight normal listeners were used as controls for the brain-damaged sample. These subjects ranged in age from 50 to 85, with an average of 64.1 yr. All subjects were native speakers of English raised in the United States and had 12–19 yr formal education. All reported normal hearing and vision.

Stimuli

The voices of 25 well-known male entertainers and politicians (e.g., Johnny Carson and John F. Kennedy) were selected from a larger set of voices used to study normal adults [9, 10]. The voice samples were low-pass filtered at 4 kHz and sampled at 10 kHz; they were then edited to create 4 sec stimuli free of pauses, background noises, and identifying content.

Response sheets consisted of vertically aligned photographs of the target speaker and three foils, randomly ordered, with typed names next to each photograph. Foils were matched to the target speaker so as to challenge the listener to actually recognize the target voice and not to use cues from content, rhetorical style (i.e., politician vs comedian) or other deductive strategies.

For each test item, BD subjects were presented with the 4-choice response sheet; the four names were then read aloud and the stimulus voice played. Response alternatives were thus made available to these subjects in visual, written and spoken forms, compensating for any specific impairments in language comprehension, facial recognition or reading. At the end of this test session all listeners were asked, for each target speaker, whether they felt they would normally recognize his voice. Responses were scored only for those voices a given listener claimed were familiar.

The unfamiliar voice stimuli consisted of 26 pairs of single sentences spoken by the same or two different males ($n = 10$) matched for age and regional accent [6, 7]. Within each sentence pair, speakers said the same thing, but different stimulus tokens were used when speakers were the same, so listeners never compared two identical stimuli. These "voices same" and "voices different" pairs were randomly ordered and occurred with equal frequency.

Order of presentation of the two tasks was counterbalanced across subjects. For both tasks, all subjects were given three practice items with feedback prior to the actual test items.

The performance measure used for the familiar voice recognition task was the percentage of known voices (for each listener) correctly recognized. For the unfamiliar voice discrimination task, the measure was the proportion of correct "same" or "different" responses.*

RESULTS

Scores for normal, LBD and RBD subjects on the recognition and discrimination tasks are shown in Table 1. Three findings from analyses of these data lead to the conclusion that

*Note that in the recognition task, chance performance floats between 25% correct and 50% correct, due to listeners' varying familiarity with the foils. Chance in the discrimination task is fixed at 50% correct. We conservatively assume that chance is set at 50% for both tasks.

Table 1. Mean raw and corrected scores for brain-damaged and normal subjects on the discrimination and recognition tasks

	Normal subjects ($N=48$) %	LBD subjects ($N=15$) %	RBD subjects ($N=11$) %	Bilateral subjects ($N=6$) %
Familiar voice recognition	82.1	81.8	62.9	62.6
Range	46.7–100	68.8–93.3	16.0–95.5	16.7–91.7
S.D.	11.39	7.93	20.00	26.73
Corrected mean scores	76.1	75.7	50.5	50.1
Unfamiliar voice discrimination	87.2	76.4	69.9	78.9
Range	53.8–100	53.8–96.2	42.3–92.3	50.0–92.3
S.D.	9.96	13.84	16.22	15.73
Corrected mean scores	74.4	52.8	39.8	57.8

performance on the two tasks is dissociated. First, performance on the discrimination and recognition tasks was only moderately correlated in normal subjects ($r=0.41$, $P<0.01$), and was not significantly correlated in LBD and RBD subjects ($r=0.20$, n.s.), suggesting no obligatory relationship between performance on one task and performance on the other.

Secondly, both LBD and RBD patients were impaired in discrimination, while only RBD patients did poorly on the recognition task (Figs 1 and 2). A two-way (group by task) repeated-measures ANOVA comparing the three groups (normal, LBD, RBD) on the two

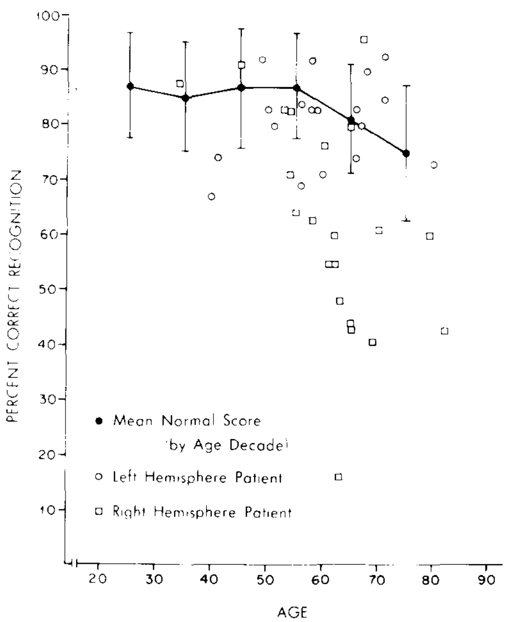

FIG. 1. Scores for unilaterally brain-damaged and normal subjects on the familiar voice recognition task. Age adjusted mean normal scores are shown as filled circles; lines give the S.D.s for scores in each age decade.

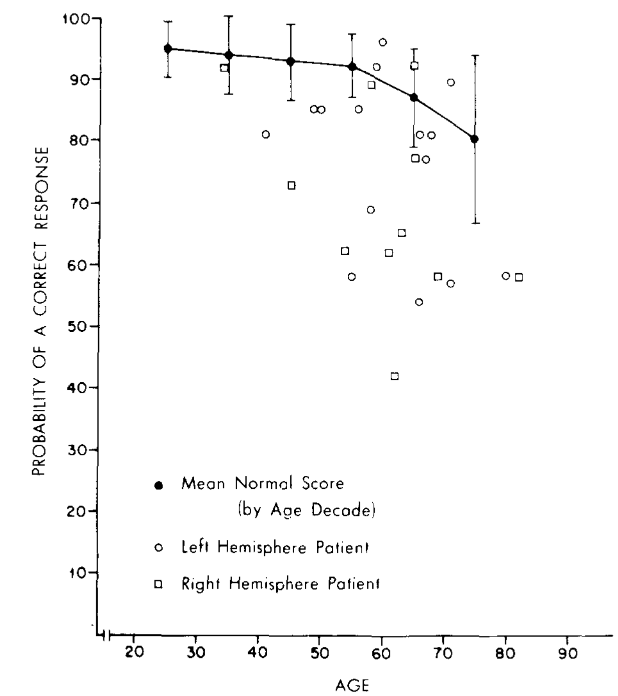

FIG. 2. Scores for unilaterally brain-damaged and normal subjects on the unfamiliar voice discrimination task. Filled circles and lines represent age-adjusted means and standard deviations for normal scores, as in Fig. 1.

experimental tasks produced significant main effects of task ($F\,(1, 71) = 1558.88$, $P < 0.01$) and group ($F\,(2, 71) = 12.98$, $P < 0.01$), as well as a significant task × group interaction ($F\,(2, 71) = 12.78$, $P < 0.01$). A study of the task × group interaction showed that both LBD and RBD groups were impaired in discrimination abilities, while only RBD subjects were impaired in recognizing familiar voices. On the discrimination task, the normal group performed significantly better than either the LBD or the RBD group (LBD: $F\,(1, 61) = 11.09$, $P < 0.01$; RBD: $F\,(1, 57) = 20.85$, $P < 0.01$); the LBD and RBD groups did not differ significantly in performance on this task. In contrast, a significant effect of hemispheric side of lesion was observed for the familiar voice recognition test: while LBD subjects did *not* differ from normals on the familiar voice recognition task ($F\,(1, 61) = 0.02$), RBD subjects performed significantly worse than either LBD or normal subjects (LBD: $F\,(1, 24) = 11.14$, $P < 0.01$; Normal: $F\,(1, 57) = 21.53$, $P < 0.01$). This outcome was further supported by a second one-way ANOVA including a larger group ($n = 39$) of LBD and RBD subjects who performed the recognition task, which also showed a main effect of group ($F\,(1, 37) = 12.66$, $P < 0.01$).

The third kind of evidence that brain damage does not have a uniform effect on discrimination and recognition abilities comes from an examination of the relative performance of the brain-damaged subjects: 44% (14 out of 32) showed a difference between scores on the two tasks which was more than 2 S.D. away from the mean normal performance difference. In contrast, only 1 out of 48 controls showed such a large discrepancy in scores. Further, discrimination was not an earlier step in an ordered sequence culminating in recognition: several patients with large discrepancies in scores could *recognize* well, but were deficient in *discrimination*. The opposite pattern also occurred, whereby patients performed in the high-to-normal range in discrimination, but were poor in familiar voice recognition. Examples are given in Table 2.

Table 2. Performance of selected brain-damaged subjects on voice discrimination and recognition tasks

	Discrimination score %	Recognition score %	Lesion side
Case number			
1	77	44	Right
2	58	84	Left
3	69	92	Left
4	58	85	Left
5	58	73	Left
6	54	83	Left
7	70	92	Left
8	50	92	Bilat.
9	73	16	Bilat.
10	89	50	Bilat.

Four patients with severe deficits on either voice recognition or voice discrimination were also tested on discrimination and recognition of faces and on environmental sound identification. No patterns of deficits across other tasks emerged, suggesting that the observed voice perception failures were not due to a general inability to discriminate or recognize or to difficulties with the task format, but rather were specific to voice perception.

DISCUSSION

The above observations indicate that brain lesions differentially affect familiar voice recognition and unfamiliar voice discrimination, leading to impaired performance in one or the other task, or in some instances in both tasks. Further, voice recognition can be achieved in the absence of an intact ability to discriminate between unfamiliar voices, indicating that the two are separate and unordered skills: discrimination cannot be a preliminary step in the familiar voice recognition process. Thus the results of this study supported the hypothesis that the two tasks engage different cerebral mechanisms.

These results are consistent with the assumption that recognizing a familiar voice may be best achieved by a pattern recognition strategy, while discriminating between unfamiliar voices may involve both featural analysis and pattern recognition. First, the association of a voice recognition deficit with RBD is consistent with research indicating that the right hemisphere is superior in pattern matching tasks [1, 2, 4, 8]. Further, both LBD and RBD groups were deficient in unfamiliar voice discrimination, possibly because that task requires both left hemisphere featural analysis and right hemisphere pattern recognition functions.

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